Wisconsin Department of Transportation

www.dot.wisconsin.gov

Scott Walker
Governor

Mark Gottlieb, P.E.
Secretary

Office of the Secretary
4802 Sheboygan Avenue, Room 120B
P O Box 7910
Madison, WI 53707-7910

Telephone: 608-266-1113
FAX: 608-266-9912
E-mail: sec.exec@dot.wi.gov

September 29, 2011

The Honorable Mary A. Lazich
Wisconsin State Senate
State Capitol, Room 8 South
Madison, WI 53707-7882

Dear Senator Lazich:

I am pleased to provide you with this copy of the Comprehensive Evaluation of Wisconsin Roundabouts study, recently completed by the University of Wisconsin – Madison's *Wisconsin Traffic Operations and Safety Laboratory*, known as the TOPS Lab.

As you know, intersection safety is a key priority for the Department, and is an important initiative in Wisconsin's Strategic Highway Safety Plan. Roundabouts are but one piece of a broader Department design safety initiative that also includes traffic signal improvements, upgrades in signing and pavement marking technologies, traffic signals that respond to varying traffic conditions, and geometric improvements.

The TOPS Lab study, conducted under contract by the Department, examined the safety of 24 roundabouts in Wisconsin that were built in 2007 or before, and yielded the following results:

- The roundabouts produced a reduction in total crashes of 9 percent, as a group.
- The roundabouts produced a reduction in fatal and injury crashes of 52 percent, including a complete elimination of fatal injury crashes at the roundabouts analyzed in the study.

The study also evaluated the operations of fourteen roundabouts, and found that drivers in Wisconsin tend to operate through roundabouts in a manner consistent with drivers in other parts of the country.

I would hasten to note that, in order to produce a sufficiently large and valid dataset for evaluation, the study focused on the oldest roundabouts in the Wisconsin highway system. The state system will feature 151 roundabouts by the end of the 2011 construction season. The Department has continuously evaluated the early roundabouts for safety and operational issues, and has built design, marking, and signage improvements into the newer roundabouts. We believe that these roundabouts will yield even more favorable results over time as we continue to refine our design standards.

The evidence shows that roundabouts in Wisconsin are saving the lives of Wisconsin motorists, when compared to traditional intersections.

The Department looks forward to providing a more complete discussion of the study results at your hearing, scheduled for next week. Please contact me if you have any questions regarding the study in the interim.

Sincerely,

Mark Gottlieb, P.E.
Secretary

WISCONSIN TRAFFIC OPERATIONS & SAFETY LABORATORY
UNIVERSITY OF WISCONSIN-MADISON
Department of Civil and Environmental Engineering

1204 Engineering Hall
1415 Engineering Drive
Madison, WI 53706

Phone: (608) 890-3425
Fax: (608) 262-5199
E-mail: bill@wisc.edu
http://www.topslab.wisc.edu

COMPREHENSIVE EVALUATION OF WISCONSIN ROUNDABOUTS

EXECUTIVE SUMMARY

Roundabouts are being installed throughout the U.S. at an aggressive pace. The primary reasons for the rapid installation of RABs are the simultaneous operations and safety benefits. This document provides an Executive Summary of the key findings from Volume 1: Traffic Operations and Volume 2: Traffic Safety.

Traffic Operations

The objective of Volume 1 of this research was to study the traffic operational characteristics of roundabouts in Wisconsin. Operational characteristics considered include critical gap, follow-up headway, and operating speeds of vehicles as they navigate roundabouts. In order to achieve the research objective, 14 roundabouts under WisDOT oversight were selected for evaluation. One of the site selection criteria was to cover most of the regions of the state, given the constraints of data collection time periods, equipment and labor availability, and traveling budget. Detailed information about the 14 roundabouts selected is given in Table 1.

Video-based analysis was chosen for the critical gap, follow-up headway, and operating speed studies. The advantage of using video included the long duration of recording, the ease of observing roundabouts from a suitable height, the ability to repeat the observation, and the accuracy of time-based video recording. Speed data were also collected through a number of speed sensors, which were correlated to the video data.

Table 2 presents the critical gap and follow-up headway results and presents the results found in NCHRP Report 572. The comparison between this research and the NCHPR Report 572 findings shows that most of the values found are consistent with the NCHRP Report 572 results. However, for both single-lane and multi-lane roundabouts, traffic congestion may lead to lower critical gap or follow-up headway values which is below the lower bound of the NCHRP Report 572 results.

In terms of the method comparison, the procedure of considering exiting vehicles decreases the critical gap and the follow-up headway values. Additionally, by considering exiting vehicles, the difference in critical gaps (or follow-up headways) among roundabout sites typically decrease.

WISCONSIN TRAFFIC OPERATIONS & SAFETY LABORATORY
UNIVERSITY OF WISCONSIN-MADISON
Department of Civil and Environmental Engineering

1204 Engineering Hall
1415 Engineering Drive
Madison, WI 53706

Phone: (608) 890-3425
Fax: (608) 262-5199
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TABLE 1 Detailed Information of Data Collection Sites

No.	WisDOT Region	Roundabout Location	Municipality	County	Number of Legs	Type
1	SW	Thompson Drive at Commercial Avenue	Madison	Dane	4	multi-lane
2	SW	Thompson Drive at STH 30 EB off-ramp	Madison	Dane	3	multi-lane
3	SW	STH 78 at CTH ID	Mt. Horeb	Dane	4	multi-lane
4	SW	US 18 at Bennett Road	Dodgeville	Iowa	4	multi-lane
5	SE	Canal Street at 25th Street	Milwaukee	Milwaukee	3	multi-lane
6	SE	Moorland Road at I-43 WB off-ramp	New Berlin	Waukesha	4	multi-lane
7	SE	Moorland Road at I-43 EB off-ramp	New Berlin	Waukesha	4	multi-lane
8	NE	STH 42 at I-43 NB off-ramp	Sheboygan	Sheboygan	4	multi-lane
9	NE	STH 42 at I-43 SB off-ramp	Sheboygan	Sheboygan	4	multi-lane
10	NE	STH 42 at Vanguard Drive	Sheboygan	Sheboygan	4	multi-lane
11	NE	CTH F at 9th Street	De Pere	Brown	4	single-lane
12	NE	STH 32 at STH 57	De Pere	Brown	4	multi-lane
13	NW	STH 53 at Old Town Hall Road	Eau Claire	Eau Claire	4	multi-lane
14	NW	STH 124 at CTH S	Chippewa Falls	Eau Claire	4	single-lane

Critical gaps and follow-up headways were compared among vehicle types. Trucks had a larger critical gap while motorcyclists had a smaller critical gap compared to passenger cars. When exiting vehicles are not considered, truck critical gaps and follow-up headways were 0.1 – 3.1 seconds and 0.6 – 1.4 seconds larger than that of passenger cars, respectively. Motorcycle critical gap and follow-up headways were 0.3 seconds and 0.8 – 1.0 seconds lower than passenger cars, respectively. When exiting vehicles are considered, truck critical gaps and follow-up headways were 0.5 – 2.2 seconds and 0.2 – 0.5 seconds larger than that of passenger cars, respectively. Motorcycles' critical gap and follow-up headways were 0.2 seconds and 0.7 – 1.2 seconds lower than that of passenger cars, respectively. Queue length was found to have no significant effects on critical gaps and follow-up headways.

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Table 2 RESULTS AND NCHRP 572 FINDINGS

	Left lane	Right lane	Approach
Critical gap in seconds (standard deviation in seconds)			
SB Canal Street at 25th Street (single-lane)			5.5 (2.0)
WB STH 78 at CTH ID (single-lane)			4.8 (1.4)
NCHRP Report 572 mean (single-lane)			5.0 (1.2)
NCHRP Report 572 range (single-lane)			4.2 – 5.9
NB STH 32 at STH 57	4.1 (1.0)	3.4 (1.0)	3.8 (1.1)
EB STH 32 at STH 57	4.2 (1.2)	3.8 (1.2)	4.0 (1.2)
WB Thompson Drive at Commercial Avenue	4.8 (1.4)	4.4 (1.5)	4.7 (1.4)
NCHRP Report 572 mean (multi-lane)	4.8 (2.1)	4.3 (1.5)	4.5 (1.7)
NCHRP Report 572 range (multi-lane)	4.2 – 5.5	3.4 – 4.9	
Follow-up headway in second (standard deviation in second)			
SB Canal Street at 25th Street (single-lane)			2.6 (1.4)
WB STH 78 at CTH ID (single-lane)			3.8 (2.6)
NCHRP Report 572 mean (single-lane)			3.2 (1.1)
NCHRP Report 572 range (single-lane)			2.6 – 4.3
NB STH 32 at STH 57	3.1 (1.3)	3.0 (1.2)	3.0 (1.2)
EB STH 32 at STH 57	2.8 (1.2)	2.8 (1.1)	2.8 (1.1)
WB Thompson Drive at Commercial Avenue	2.5 (1.4)	2.2 (0.5)	2.4 (1.3)
NCHRP Report 572 mean (multi-lane)	3.2 (1.1)	3.0 (1.2)	3.1 (1.1)
NCHRP Report 572 range (multi-lane)	2.9 – 5.0	2.8 – 4.4	

In the fastest path study, operating speeds at three longitudinal positions were collected as presented in Table 3. Three patterns of the operating speeds were shown when the operating speeds are categorized based on the flatness of path. First, when the through path is of adequate curvature, vehicles slow down at the entrance, further decelerate in the circulating roadway, and recover to a higher speed at the exit. Second, when the through paths reach certain flatness levels, vehicles no longer need to slow down in the circulating roadway; therefore, speeds increase along the three longitudinal positions. Third, as flatness score (FS) increases; operating speeds tend to increase at each of the three longitudinal positions. Additionally, the comparison between operating speeds and design speeds shows that the design speeds based on fastest path are at different percentiles of operating speeds at different longitudinal positions. Design speeds were near the 95th percentile of the operating speeds at the entrance, 60th – 80th percentile at the mid-circulating roadway, and 45th – 70th percentile at the exit. Further, the average operating speed at the highest FS was controlled under the design speed at the entrance but not at the mid-circulating roadway. This relationship varied at roundabout exits.

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UNIVERSITY OF WISCONSIN-MADISON
Department of Civil and Environmental Engineering

1204 Engineering Hall
1415 Engineering Drive
Madison, WI 53706

Phone: (608) 890-3425
Fax: (608) 262-5199
E-mail: bill@wisc.edu
http://www.topslab.wisc.edu

TABLE 3 Average Operating Speeds by Longitudinal Position and Flatness Score

FS	Sample Size	Entrance		Mid-circulating		Exit	
		Average Speed (mph)	Standard Deviation (mph)	Average Speed (mph)	Standard Deviation (mph)	Average Speed (mph)	Standard Deviation (mph)
WB through vehicles of US 18 at Bennett Road							
All	193	22	5	19	4	25	5
0	93	22	5	17	4	24	3
1	24	23	5	19	3	27	8
2	52	22	5	19	4	25	4
3	12	23	6	19	4	26	8
4	10	24	4	27	5	27	4
5	2	28	1	23	8	35	13
SB through vehicles of STH 42 at Vanguard Drive							
All	270	20	6	21	5	26	6
-2	1	13	n/a	12	n/a	16	n/a
-1	1	33	n/a	18	n/a	23	n/a
0	230	20	6	20	4	25	6
1	1	26	n/a	18	n/a	25	n/a
2	22	20	6	22	7	29	9
4	15	25	4	26	4	28	4

Safety

The objective of Volume 2 of this research was to study the traffic safety characteristics of roundabouts in Wisconsin. While roundabouts are still fairly new in the U.S. and Wisconsin, their safety benefits have been studied with varied results. For this study, researchers analyzed 24 roundabouts that were built in 2007 or before. Three years of before and after crash data were gathered as well as geometric and volume data. An Empirical Bayes (EB) analysis was used to examine the safety benefits for total crashes and injury (K, A, B, C) crashes. A simple before-and-after crash analysis was also completed to analyze specific types of injury crashes for each roundabout. Detailed information about the 24 roundabouts selected is given in Table 1.

WISCONSIN TRAFFIC OPERATIONS & SAFETY LABORATORY
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TABLE 4 Roundabout Characteristics

						REQUIRED (for Intersection Safety Performance Function Base Conditions)											
							AADT-Before			AADT-After							
STD #	Roundabout Name (Streets)	Region	County	Years of Before Crash Data	Year of After Crash Data	Roundabout Open to the Traffic	AADT-Major	AADT-Minor	AADT-Total	AADT-Major	AADT-Minor	AADT-Total	Number of Lanes	Area Type	Number of Legs	Intersection Traffic Control Before	High Speed
2	17/2ND AND GAYNOR	NC	Wood	2001-2003	2005-2007	9/15/2006	17,875	3,875	21,750	12,500	5,600	18,100	2	3	4	2	
4	MATTHEW AND NINTH AND CTH F (SCHEURING)	NE	Brown	2001-2003	2003-2007	11/1/2004	8,700	3,300	12,000	10,100	1,800	11,900	1	3	4	2	
5	SUBURBAN AND CTH F (SCHUERING)	NE	Brown	2001-2003	2005-2007	11/1/2004	7,400	3,750	10,650	6,450	1,800	8,250	1	3	4	2	
6	STH 32/57 (GREENLEAF) & STH 96 (DAY)	NE	Brown	2004-2006	2008-2010	8/31/2007	7,250	3,500	10,750	7,250	3,500	10,750	1	3	4	3	Y
7	USH 141 & ALLOUEZ AVE	NE	Brown	2004-2006	2008-2010	10/1/2007	7,000	1,700	8,700	10,100	3,500	13,600	1	1	4	2	Y
8	STH 32/57 (CLAUDE ALLOUEZ) & BROADWAY	NE	Brown	2004-2006	2008-2010	7/12/2007	32,500	15,600	48,100	50,000	24,900	74,900	2	3	4	4	
9	STH 55 & CTH KK	NE	Calumet	2003-2005	2007-2009	8/3/2006	10,800	4,500	14,800	8,950	3,650	12,600	1	1	4	2	Y
10	CTH EP/LAKE PARK & CTH P/PLANK	NE	Calumet	2004-2006	2008-2010	11/1/2007	8,250	3,050	12,100	7,300	4,450	11,750	1	2	4	2	Y
12	CTH N / Emons Road	NE	Outagamie	2004-2006	2008-2010	8/31/2007	7,800	800	8,600	12,200	2,100	14,300	1	1	4	2	
15	STH 28 & STH 32	NE	Sheboygan	2003-2005	2007-2009	9/1/2006	8,850	2,950	11,800	5,300	3,750	9,050	1	1	4	2	Y
17	STH 42 & I 43 RAMPS (West)*	NE	Sheboygan	2004-2006	2008-2010	11/2/2007	10,700	1,800	12,000	23,000	3,000	26,000	2	1	4	4	
41	STH 42 & I 43 RAMPS (East)*	NE	Sheboygan	2004-2006	2008-2010	11/2/2007	15,100	4,700	19,800	20,000	8,076	28,076	2	1	4	4	
18	STH 42 & VANGUARD Wal-Mart Entrance	NE	Sheboygan	2004-2006	2008-2010	11/3/2007	11,600	1,500	13,100	20,000	7,000	27,000	2	1	4	4	Y
19	BREESE/ODD & TULLAR	NE	Winnebago	2002-2004	2006-2008	9/15/2005	13,000	4,600	17,600	11,350	4,800	16,150	1	3	4	1	
20	USH 53 & CTH O RAMPS (west)*	NW	Baron	2003-2005	2007-2009	6/1/2006	7,300	3,100	10,400	7,770	3,299	11,069	1	3	4	2	Y
21	USH 53 & CTH O RAMPS (east)*	NW	Baron	2003-2005	2007-2009	6/1/2006	12,650	2,600	15,450	14,200	3,000	17,200	1	3	4	2	Y
22	STH 124 & CTH S	NW	Chippewa	2003-2005	2006-2008	10/15/2005	8,250	3,600	11,850	5,100	4,700	9,800	1	1	4	2	Y
27	CANAL AND 25TH ST.	SE	Milwaukee	2003-2005	2006-2008	9/15/2005	13,600	10,500	24,100	18,400	4,900	23,300	2	3	3	3	
28	STH 38 & CTH K(NORTHWESTERN)	SE	Racine	2004-2006	2008-2010	11/15/2007	14,200	2,300	16,500	8,960	4,160	13,120	2	3	3	2	Y
29	Elkhorn Rd (Bus 12)/Bluff Rd/Clay St	SE	Walworth	2004-2006	2008-2010	10/15/2007	10,050	2,100	12,150	7,100	2,100	9,200	2	2	4	1	Y
35	STH 92/8TH AND STH 92/SPRINGDALE	SW	Dane	2001-2003	2005-2007	4/27/2004	20,000	8,000	28,000	17,400	6,650	24,050	2	3	4	4	
36	THOMPSON AND COMMERICAL	SW	Dane	2001-2003	2005-2007	10/18/2004	14,000	4,108	18,108	15,500	9,600	25,100	2	3	4	3	
37	THOMPSON AND STH 30	SW	Dane	2001-2003	2005-2007	10/18/2004	9,695	4,284	13,979	13,575	3,300	16,875	2	3	3	3	
38	USH 12 RAMP & PARMENTER	SW	Dane	2003-2005	2007-2009	10/15/2006	10,200	4,500	14,700	9,000	5,950	14,950	2	3	4	3	Y

Area Type: 1. Rural, 2. Suburban, 3. Urban
Intersection Traffic Control Before: 1. No Control or yield, 2. Minor Road Stop Control (TWSC), 3. All-Way Stop Control (AWSC), 4. Signalized Intersection

For the simple before-and-after crash analysis, researchers found that none of the sites observed any fatal crashes after the installation. For all injury (A, B, and C) crashes, the number of locations with reduced crashes is greater than the number of locations with increased crashes. The magnitude of decrease in injury crashes is higher than the magnitude of increase. When examining crash type, researchers found that roundabouts changed the crash types that can occur at intersections from more severe crash types like angle and head-on to less severe crash types such as no collision and sideswipe same direction. Table 5 shows the simple before-and-after crash analysis for each of the roundabouts.

The EB analysis was performed using Safety Performance Functions (SPFs) from both the Highway Safety Manual (HSM) and Wisconsin specific data. The results from both values were very similar adding strength to the numbers. Using the HSM SPFs, researchers found mixed results for total crash frequency but a significant decrease in crash severity. Nationally, 35% reduction was observed for all crashes as noted in NCHRP Report 572 while Wisconsin roundabouts showed a 9% decrease across the 24 roundabouts. Wisconsin RABs had a decrease of 52% for fatal and injury crashes. Roundabouts nationwide are also experiencing a significant decrease in severe crashes. The EB Analysis for Fatal and Injury Crashes is shown in Table 6.

WISCONSIN TRAFFIC OPERATIONS & SAFETY LABORATORY
UNIVERSITY OF WISCONSIN-MADISON
Department of Civil and Environmental Engineering

1204 Engineering Hall
1415 Engineering Drive
Madison, WI 53706

Phone: (608) 890-3425
Fax: (608) 262-5199
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TABLE 5 Simple Before-and-After Crash Data

Roundabout	WisDOT Region	Before						After					
		K	A	B	C	PDO	Total	K	A	B	C	PDO	Total
STH 54/Gaynor St/17th St	NC			2	6	9	17					20	20
CTH F/S. Ninth St.	NE			1			1			1	2	1	4
CTH F/Suburban Dr.	NE					2	2						
STH 32/57 and STH 96	NE			1		6	7			1	1	6	8
STH 141 / Allouez Ave	NE		1	1	1	9	12			1	2	8	11
STH 32/STH 57 Broadway	NE				1	8	9				3	40	43
STH 55/CTH KK	NE	1	1	4	5	9	20			1		4	5
Lake Park/Plank Rd (CTH LP/CTH P)	NE									1		2	3
CTH N / Emons Road	NE			1	1		2			2		3	5
STH 28/32 (high speed)	NE			1	1	6	8				1	10	11
STH 42/ I-43, Interchange Ramps (West)*	NE			1	1	7.5	9.5			1	3.5	8	12.5
STH 42/ I-43, Interchange Ramps (East)*	NE			1	1	13.5	15.5		2	1	0.5	12	15.5
STH 42/Vanguard, Wal-Mart entrance	NE				1	1	2					8	8
Breezewood ln/Tullar Rd	NE				2	2	4					6	6
US 53 ramps and CTH O (West)*	NW				1	9.5	10.5			1	0.5	2	3.5
~~US 53 ramps and CTH O (East)*~~	~~NW~~					~~5.5~~	~~5.5~~			~~1~~	~~1.5~~	~~2~~	~~4.5~~
STH 124/CTH S	NW		1	2	8	5	16				1	5	6
Canal St/25th Ave	SE					1	1				2	11	13
STH 38/CTH K	SE			3	6	19	28		1		1	18	20
Elkhorn Rd (Bus 12)/Bluff Rd/Clay St	SE		1			2	3					3	3
STH 78/STH 92, 8th St, Springdale, CTH JD	SW			1		13	14					11	11
Thompson and Commercial (North)	SW	1	1	3	7	8	20		1		6	32	39
Thompson and STH 30 (South)	SW			1	4	8	13				1	7	8
Old STH 12/Parmenter	SW			3	1	5	9					2	2
Grand Total		2	5	26	47	149	229	0	4	11	26	221	262

*Crashes at interchange ramp terminals that could not be ascribed to a particular roundabout were assigned as 0.5 to each roundabout.

When looking at predictor variables, the speed limit of the approaches did not show a significant impact on the safety of the roundabouts. While multi-lane roundabouts seem to be safer than single lane roundabouts when looking at fatal and injury crashes, single lane roundabouts saw a larger decrease in total crashes. TWSC conversions had the highest safety benefit as compared to AWSC and signalized.

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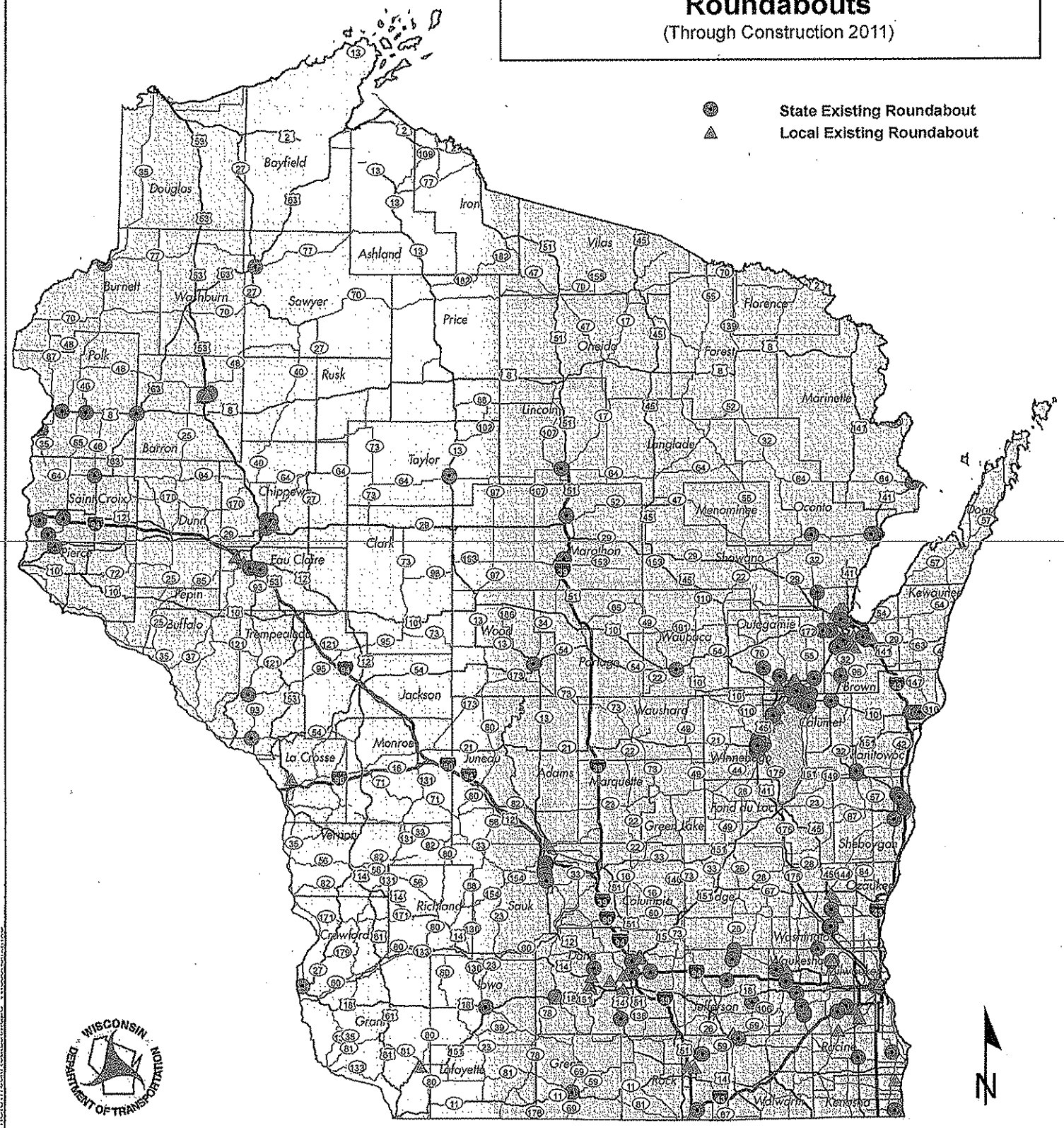
TABLE 6 EB Analysis for Fatal and Injury Crashes

Location	Intersection Type	Observed Fatal and Injury Crashes-Before	Expected Crashes –EB-After	Observed Fatal and Injury Crashes-After	B-A	B-A [% Reduction=100(B-A)/B]
STH 54/Gaynor St/17th St	4Urb4ST	8.00	5.273	0.00	5.27	100.00
CTH F/S. Ninth St.	2Urb4ST	1.00	1.449	3.00	-1.55	-107.00
CTH F/Suburban Dr.	2Urb4ST	0.00	0.694	0.00	0.69	100.00
STH 32/57 and STH 96	2Urb4STALL	1.00	1.300	2.00	-0.70	-53.90
STH 141 / Allouez Ave	2Rur4ST	3.00	2.973	3.00	-0.03	-0.92
~~STH 32/STH 57 Broadway~~	~~4Urb4SG~~	~~1.00~~	~~5.751~~	~~3.00~~	~~2.75~~	~~47.83~~
STH 55/CTH KK (high speed)	2Rur4ST	11.00	2.809	1.00	1.81	64.40
Lake Park/Plank Rd (CTH LP/CTH P)	2Urb4ST	0.00	0.936	1.00	-0.06	-6.87
CTH N / Emons Road	2Rur4ST	2.00	2.743	2.00	0.74	27.10
STH 28/32 (high speed)	2Rur4ST	2.00	1.993	1.00	0.99	49.83
STH 42/ I-43, Interchange Ramps (West)	4Rur4SG	2.00	8.894	4.50	4.39	49.40
STH 42/ I-43, Interchange Ramps (East)	4Rur4SG	2.00	6.996	3.50	3.50	49.97
STH 42/Vanguard, Wal-Mart entrance	4Rur4SG	1.00	7.921	0.00	7.92	100.00
Breezewood ln/Tullar Rd	2Urb4YD	2.00	2.170	0.00	2.17	100.00
US 53 ramps and CTH O (West)	2Urb4ST	1.00	1.463	1.50	-0.04	-2.55
US 53 ramps and CTH O (East)	2Urb4ST	0.00	1.329	2.50	-1.17	-88.10
STH 124/CTH S	2Rur4ST	11.00	2.146	1.00	1.15	53.40
Canal St/25th Ave	4Urb3STALL	0.00	1.431	2.00	-0.57	-39.78
STH 38/CTH K	4Urb3ST	9.00	3.897	2.00	1.90	48.68
Elkhorn Rd (Bus 12)/Bluff Rd/Clay St	4Urb4YD	1.00	1.086	0.00	1.09	100.00
STH 78/STH 92, 8th St, Springdale, CTH ID	4Urb4SG	1.00	2.054	0.00	2.05	100.00
Thompson and Commercial (North)	4Urb4STALL	12.00	9.644	7.00	2.64	27.42
Thompson and STH 30 (South)	4Urb3STALL	5.00	6.819	1.00	5.82	85.34
Old STH 12/Parmenter	4Urb4STALL	4.00	2.865	0.00	2.87	100.00

STATE OF WISCONSIN

Roundabouts

(Through Construction 2011)



WISCONSIN DEPARTMENT OF TRANSPORTATION

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